

GOES-R AWG Product Validation Tool Development

Lightning Application Team

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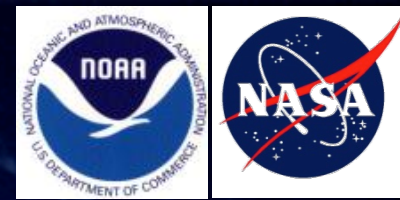
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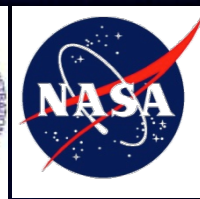
OVERVIEW



- **Products**
- **Validation Strategies**
- **Routine Validation Tools**
- **“Deep-Dive” Validation Tools**
- **Further Enhancement and Utility of Validation Tools**
- **Summary**



Products

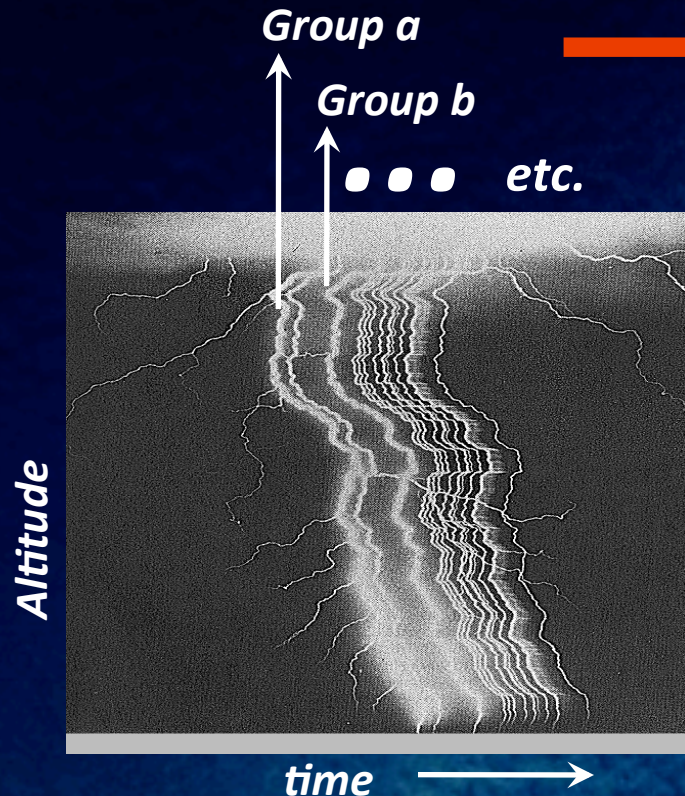
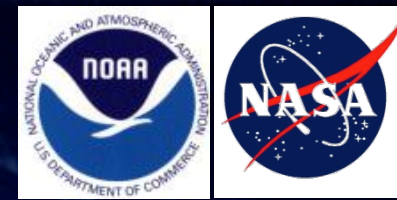


Lightning Optical: Events, Groups, and Flashes

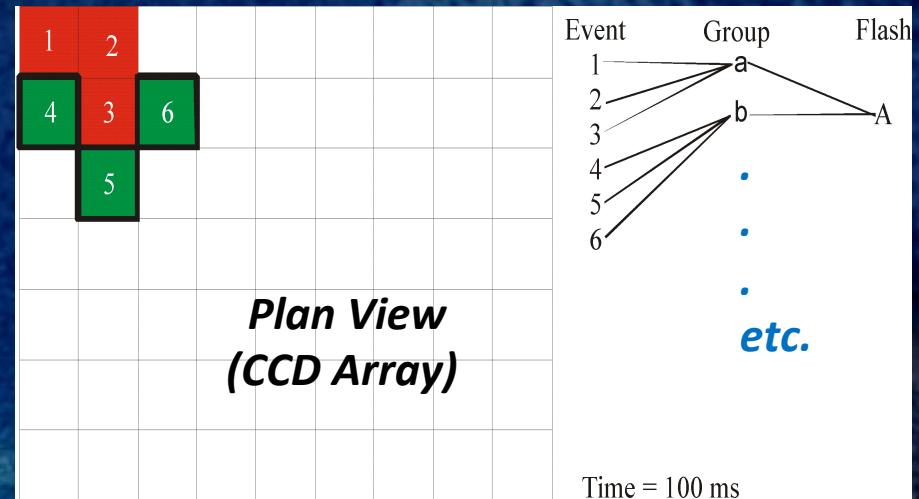
Product Statistics Qualifier	Cloud Cover Conditions Qualifier	Product Extent Qualifier	Temporal Coverage Qualifiers	Measurement Precision	VAGL	Product Refresh Rate / Coverage Time	Measurement Accuracy	Measurement Range	Mapping Accuracy	Horizontal Resolution	Vertical Resolution	Product Geographic Coverage	User & Priority	Name
Over lightning cases and mesoscale-sized surrounding regions	Cloud cover conditions permitting obs. of lightning associated with threshold accuracy	Quantitative out to at least 65 degrees LZA and qualitative beyond	Day and night	5% (Std. Dev. of FDE)	20 sec	Continuous	70% minimum Flash Detection Efficiency (FDE)	Real Time	5 km	10 km	Sfc to Cloud Top.	Full Disk	GOES -R	Lightning Detection -Events -Groups -Flashes



Products (cont.)



Groups Help Track Strokes & other components of the flash.

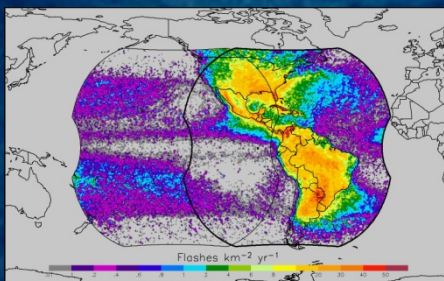


Event: The occurrence of a single pixel exceeding the background threshold during a single frame

Group: Two or more adjacent events in the same time frame

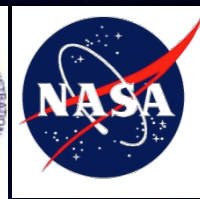
Flash: A set of groups sequentially separated in time by no more than 330 ms and in space by no more than 16.5 km

GLM
FOV
(1372 x 1300)





Val Data



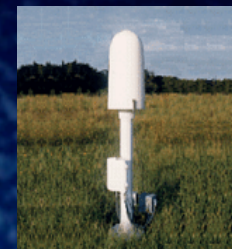
□ Ground Truth Datasets:

➤ Short-Medium Range Lightning

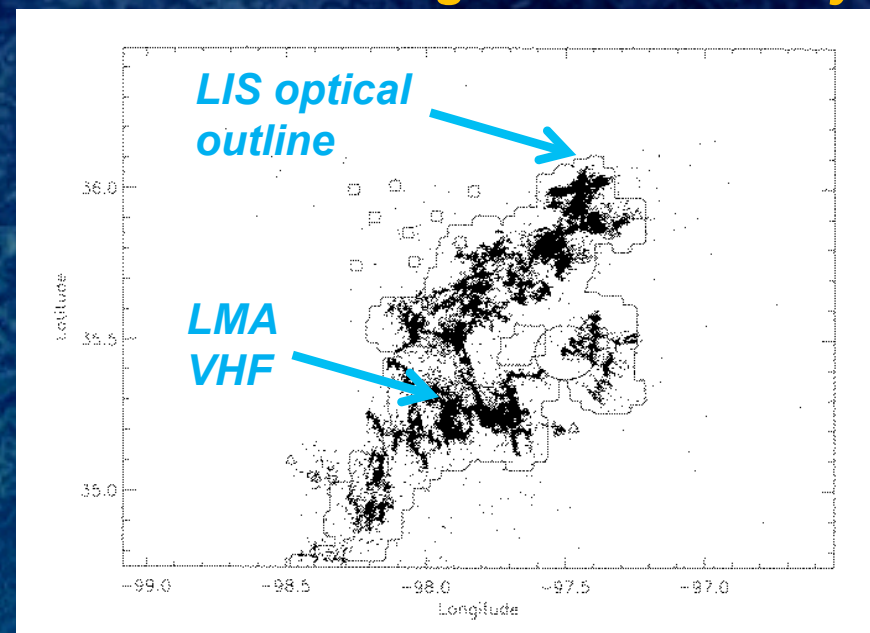
- ✓ LMA (North Alabama, Oklahoma, DC, West Texas)
- ✓ LDAR II (KSC Florida)
- ✓ HAMMA (North Alabama)
- ✓ High Speed Video Cameras
- ✓ KSC Field Mills (KSC Florida)
- ✓ NLDN (CONUS)

➤ Long Range Lightning

- ✓ GLD360
- ✓ WWLLN
- ✓ WTLN

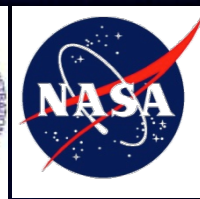


Also for Building the GLM Proxy

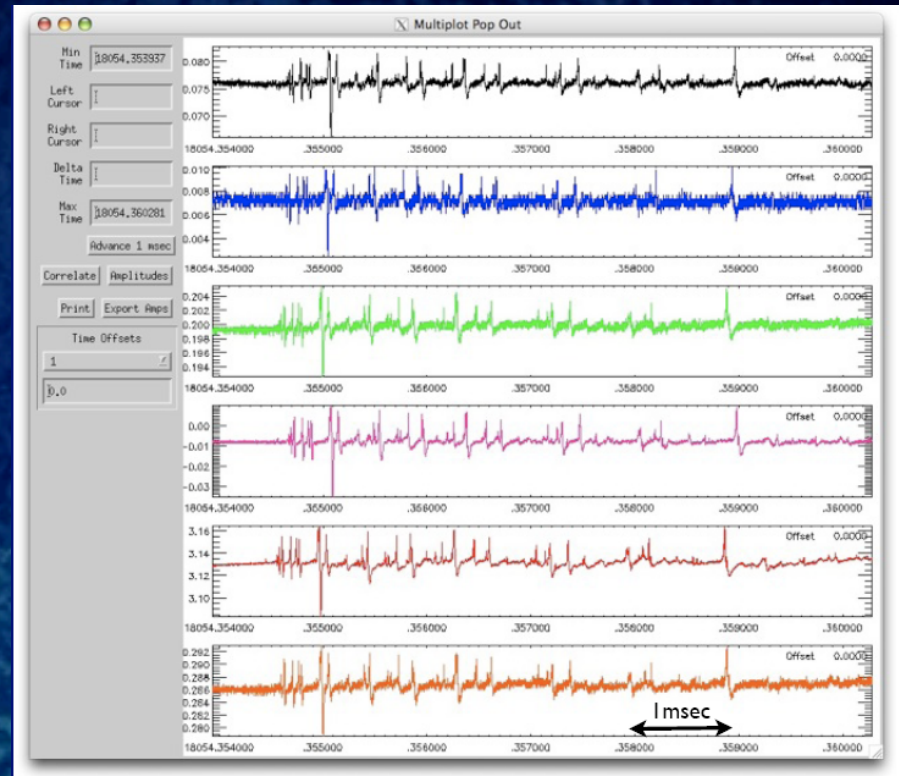




HAMMA Network (Huntsville Alabama Marx Meter Array)

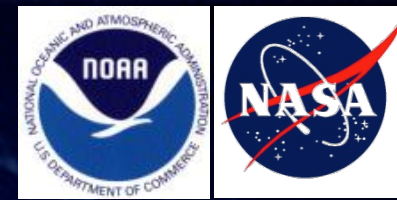


- 6 station network in N. Alabama
- More information content than LMA
- Can see preliminary breakdown, return stroke, and electrostatic changes
- Used as a time-of-arrival (x,y,z,t) RF source retrieval system
- Also provides electrostatic field changes to retrieve lightning charge
- Will use to determine what part of lightning process GLM detects
- Will also use to examine GLM detection sensitivity & continuing currents





Val Data (cont.)



□ Additional Ground-Based Systems for Field Campaigns

- CHUVA (beginning Oct 2011)
 - ✓ SPLMA (Sao Paulo Brazil)
- DC3 (May-June, 2012)
 - ✓ FCLMA (Fort Collins Colorado)
- HyMeX (beginning Sept 2012)
 - ✓ Possible deployment of MLMA (Mediterranean region)





Val Data (cont.)



□ Airborne GLM Simulator

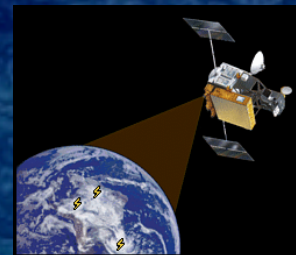


- Build an airborne detection system that will make high resolution optical measurements as a GLM simulator.
- Deploy on aircraft (e.g., ER2, Global Hawk) to observe cloud-top lightning pulses (target DC3, HS3, other field campaigns).

□ Satellite Observations

➤ LIS

- ✓ GLM proxy data development
- ✓ Pre-launch validation simulations (including val tool testing)
- ✓ Pursue opportunity to a LIS on International Space Station



Credit: CNES/III. D. Ducros

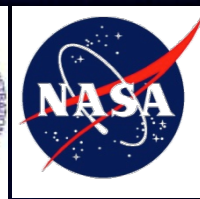
➤ TARANIS (Tool for the Analysis of Radiation from lightNing and Sprites)

- ✓ Launch 2015, CNES/France; nadir staring (2 cameras, 4 photometers)
- ✓ Directly compare with GLM data

➤ Cross-calibration between GLM and MTG LI (2017)



Definitions: Basic Val Tool Types



❑ GLM Proxy Creation Tool

- A tool used to create simulated GLM data (level 1b or level 2).

❑ LCFA Performance Validation Tool

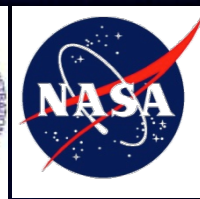
- A tool that validates the performance of the Lightning Cluster Filter Algorithm (LCFA) using either simulated or actual GLM data.
 - ✓ Important: only the LCFA in isolation is being validated by these tools.
 - ✓ The Algorithm Implementation & Test Plan Document already describes some of these tools (and LCFA performance results); LCFA resiliency, accuracy, and speed were characterized.

❑ GLM Validation Tool

- A tool that validates the end-to-end performance of the GLM using either lab-simulated or actual GLM data.
 - ✓ Validation can employ ground, air-borne, or satellite truths.
 - ✓ Both level 1b and level 2 data are evaluated.



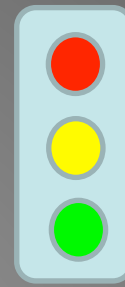
Routine Validation Tools



❑ **Lightning Monitoring Tool (LMT)** will monitor the following:

- Instrument Health/Operation: by ingesting housekeeping and other meta-data on continuous basis.
- Instrument Degradation: using periodic reports on DCC analyses (& other physical target analyses) that flag instrument degradation.
- Individual Pixel Sensitivity: using periodic reports on pixel fidelity.
- GLM Products: using truth data and the VaLiD shallow dive “engine” (see later).
 - ✓ Display any problem with the LCFA by monitoring flags (metadata) in the L2 stream that communicate problems (time, space and overflow) in the clustering process.
 - ✓ Will routinely report on lightning product statistics and assess reasonableness.
 - ✓ Compare GLM to other available data (e.g., clouds, other lightning data) to verify that GLM is seeing lightning where expected (and vice-versa).
- INR: using periodic reports on IR background (from ABI, GLM).
- INR: using periodic reports from laser beacon analyses.
- INR: using lightning NLDN/LMA ground truth @ night (if needed).

Lightning Monitoring Tool (LMT)



**"STOP LIGHT"
ALERTs**

Instrument Health/ Operation (CONTINUOUS)

Instrument Degradation

- DCC radiance analyses
- deserts, other targets
- pixel sensitivity logging

VaLiD

- Shallow dive mode
- Deep dive mode

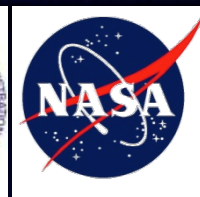
INR flagging

- ABI/GLM background
- Lasers
- Nocturnal lightning

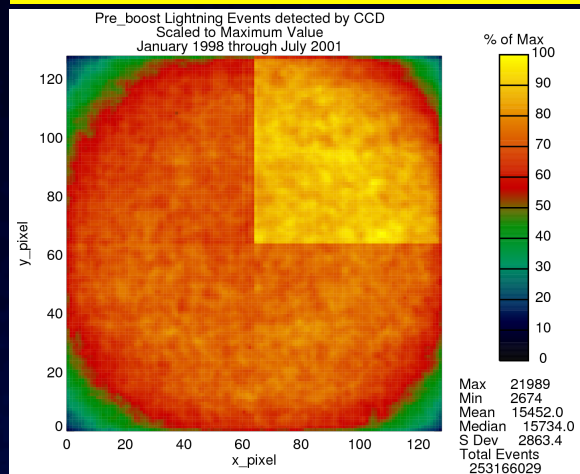
The "stop light" alert output of the LMT is based on inputs (white arrows) the LMT receives. A red or yellow alert could trigger more in-depth "deep dive" analyses.



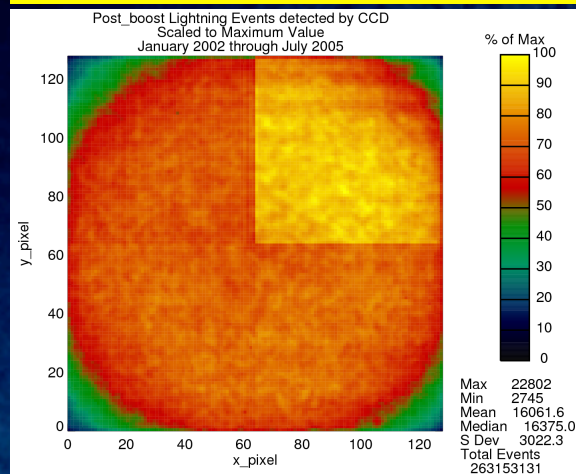
Monitoring Pixel Sensitivity



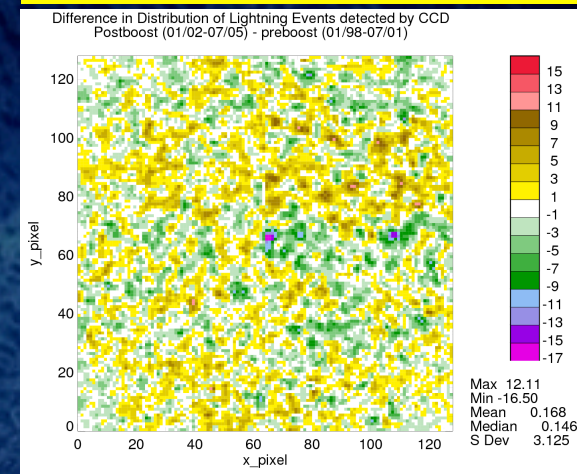
pre-boost (Jan 98 - July 01) pixel array



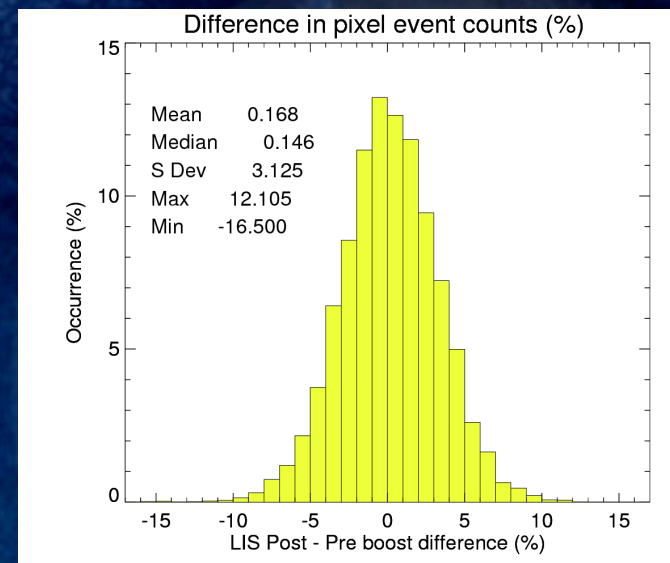
post-boost pixel array (Jan 02 - July 05)



post-boost - pre-boost

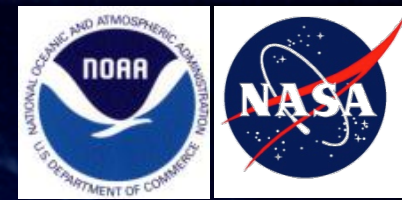


- **TRMM/LIS Ex.- Time period for the post boost same as the pre-boost so that the amount of time analyzed would be the same**
- **Filtered data (i.e. Events that made it through all the various filters and ended up in flashes) at each pixel in the CCD array**
- **CCD values scaled by the maximum value to get a percent of maximum.**





Analytical Validation Tools

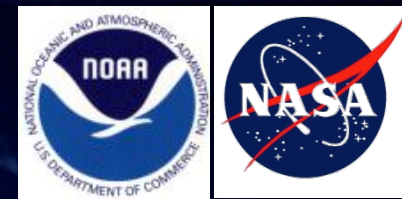


□ VaLiD — “Shallow Dive” mode

- VaLiD = Validate Lightning Detection
- Will ingest data from multiple sources
 - ✓ Ground: NLDN, WWLLN, WTLN, various LMA
 - ✓ Space: LIS (if available)
- Will plot some/all these data with GLM data (as desired by operator)
- Will show lightning totals and trends
- Can click on the live map and trigger “Deep Dive” mode



Analytical Validation Tools

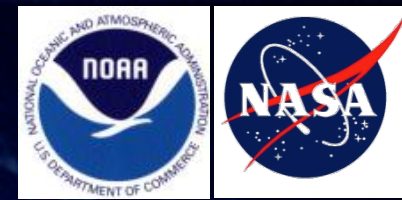


□ VaLiD — “Deep Dive” mode

- Will be able to look at individual events, groups and flashes to assess resiliency, accuracy and speed
- Plot products, LMA flashes/sources and/or other available/selected data (NLDN, WTLN, WWLLN, HAMMA, etc.)
- Will give a flash-by-flash assessment of the inter-system comparison of all lightning detection systems
- Will be able to assess flash detection efficiency



Pre-Launch Validation Tools

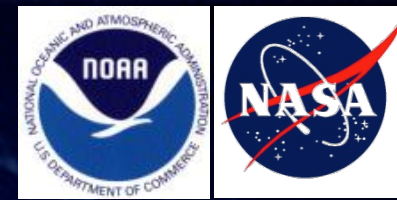


V1 Complete

- Current proxy is based on LMA data
- Have tools that validate GLM proxy pixels (L1b) and proxy flashes (L2)
- Also assesses resiliency, accuracy & speed of the LCFA
- Assesses the quality of the proxy pixels (L1b) — realistic? challenging enough to stress the LCFA?
- (v2) Need to generate L1b pixels from other sources besides (NA)LMA
- (v2) Need to run these proxies through VaLiD to test it



Post-Launch Validation Tools



- VaLiD and the LMT need to be functioning
- They will need to be "tweaked" post-launch (cannot guess alert thresholds pre-launch)
- May be able to also use satellite images (or GLM background images) to enhance both tools



Further Enhancement and Utility of Validation Tools



ZOOM Feature as presently done for LIS ...

1. Click a location & period
2. Define box dimensions
3. Spill out **stats** for box



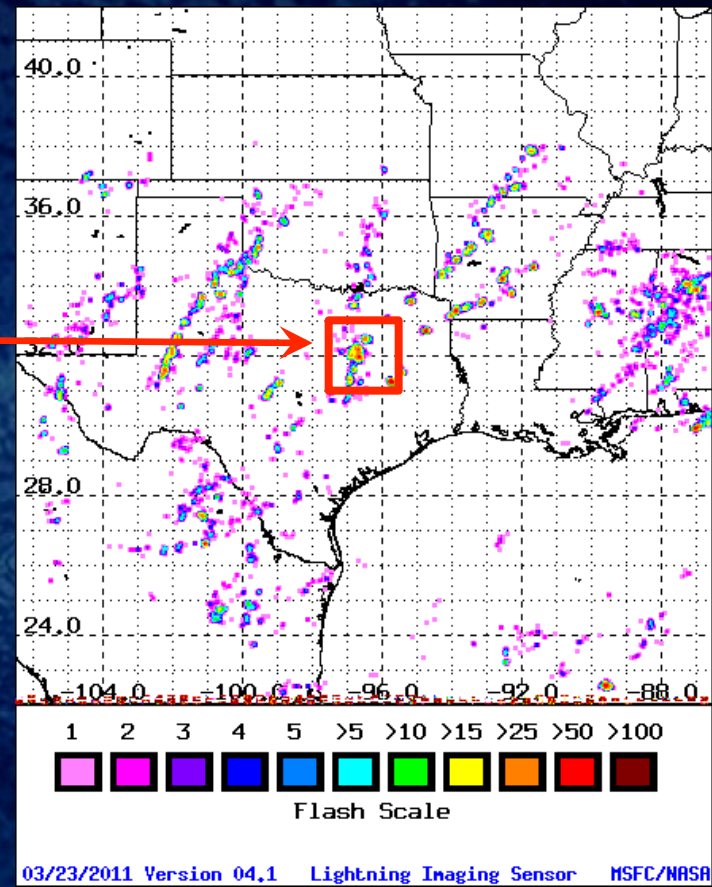
Search Area
 Center : (32.000,-96.500)
 Diagonal : (31.000,-97.500) - (33.000,-95.500)

Search Day and Night time
 2010 April [Day of Year 091 - 120]

Table pertains to flashes in the area of interest, (red rectangle on the image).

Granule Name	Start time (UTC)	End Time (UTC)	Flashes
TRMM LIS SC.04.1 2010.114.70856 [Apr 24]	2010-114T00:26:07Z	2010-114T02:00:17Z	142
TRMM LIS SC.04.1 2010.114.70858 [Apr 24]	2010-114T03:30:57Z	2010-114T05:05:00Z	8
TRMM LIS SC.04.1 2010.114.70859 [Apr 24]	2010-114T05:03:15Z	2010-114T06:37:25Z	450
TRMM LIS SC.04.1 2010.116.70902 [Apr 26]	2010-116T23:16:15Z	2010-117T00:50:24Z	10

Total granules with flashes detected in the area of, (red rectangle) interest 4.
 Total flashes detected in the area of interest, (red rectangle) 610.
 Total flashes in image 5932.





Summary



- ❑ Goal of GLM validation is to ensure that GLM products (events, groups, flashes)
 - are adequately detected
 - accurately located in space and time, and with proper latency
- ❑ To accomplish this, we are developing various val tool types:
 - GLM proxy creation tool
 - LCFA performance validation tool
 - GLM validation tool
- ❑ These tools require many truth datasets:
 - ground
 - air-borne
 - satellite
- ❑ Our coordinated efforts will lead to development of Lightning Monitoring Tool (LMT) which relies on several routine analyses and aperiodic data reports that involve both “shallow and deep dive” investigations.